

Chemistry
Higher level
Paper 1

Wednesday 16 May 2018 (afternoon)

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[40 marks]**.

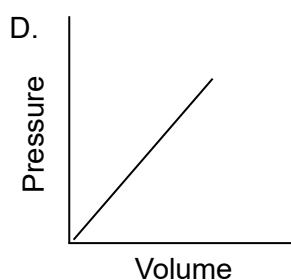
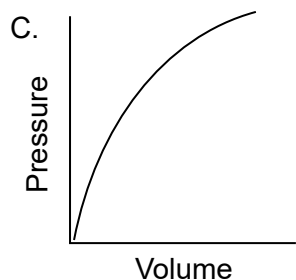
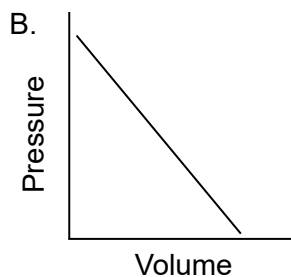
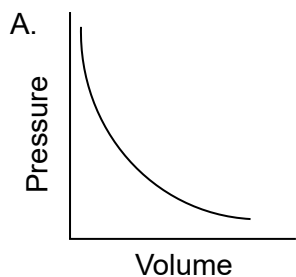
The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18			
1	1 H 1.01	Atòmic number																	2 He 4.00		
2	3 Li 6.94	4 Be 9.01	Element																	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31	Relative atomic mass																	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.90			
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29			
6	55 Cs 132.91	56 Ba 137.33	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)			
7	87 Fr (223)	88 Ra (226)	89 † Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (269)	109 Mt (278)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Uut (286)	114 Uug (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 Uuo (294)			
†	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97							
‡	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)							

1. What is the molecular formula of a hydrocarbon containing 84.6% carbon by mass with a molar mass of 142.3 g mol^{-1} ?

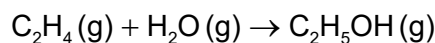
- A. $\text{C}_{20}\text{H}_{44}$
- B. $\text{C}_{11}\text{H}_{10}$
- C. $\text{C}_{10}\text{H}_{22}$
- D. C_5H_{11}

2. Which graph shows the relationship between the volume and pressure of a fixed mass of an ideal gas?



3. What is the percentage yield when 7 g of ethene produces 6 g of ethanol?

M_r (ethene) = 28 and M_r (ethanol) = 46



- A. $\frac{6 \times 7 \times 100}{28 \times 46}$
- B. $\frac{6 \times 46 \times 100}{7 \times 28}$
- C. $\frac{6 \times 28}{7 \times 46 \times 100}$
- D. $\frac{6 \times 28 \times 100}{7 \times 46}$

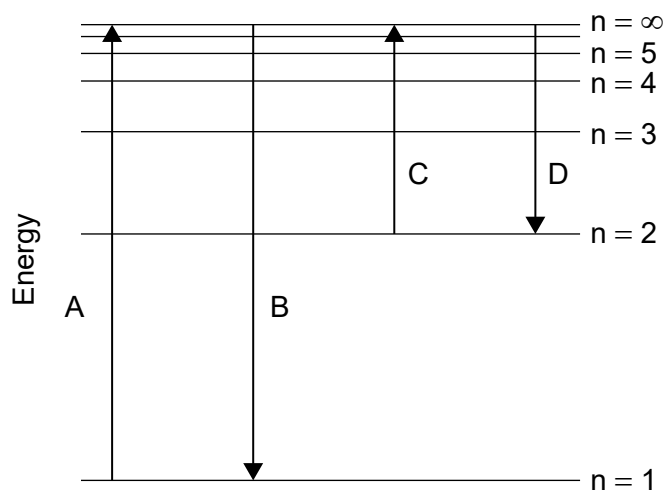
Turn over

4. Which are correct statements about the emission spectrum of hydrogen in the visible region?

- I. The red line has a lower energy than the blue line.
- II. The lines converge at longer wavelength.
- III. The frequency of the blue line is greater than the frequency of the red line.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

5. Which transition on the diagram corresponds to the ionization of hydrogen in the ground state?



6. Which describes the oxide of sodium, Na₂O?

	Bonding	Conduction of electricity (pure substance)	pH of aqueous solution
A.	covalent	as a solid and liquid	low
B.	covalent	as a solid only	high
C.	ionic	as a solid and liquid	low
D.	ionic	as a liquid only	high

7. Which statement is correct?
- A. Atomic radius decreases down group 17.
 - B. First ionization energy decreases down group 1.
 - C. Atomic radius increases across period 3 from Na to Cl.
 - D. First ionization energy decreases across period 3 from Na to Cl.
8. Which complex has the greatest d orbital splitting?

	Complex	Oxidation state of metal	Colour of complex
A.	$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$	+2	green
B.	$[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$	+3	orange
C.	$[\text{Co}(\text{H}_2\text{O})_6]^{3+}$	+3	blue
D.	$[\text{Cr}(\text{NH}_3)_6]^{3+}$	+3	violet

9. Which form of carbon is the poorest electrical conductor?
- A. Graphite
 - B. Graphene
 - C. Diamond
 - D. Carbon nanotube

10. What is the molecular geometry and bond angle in the molecular ion NO_3^- ?

	Molecular geometry	Bond angle
A.	tetrahedral	109.5°
B.	trigonal planar	120°
C.	trigonal pyramidal	107°
D.	trigonal planar	109.5°

Turn over

11. Which metal has the strongest metallic bonding?

- A. Na
- B. Mg
- C. Al
- D. Ca

12. Which molecules have at least one sp^2 hybridized atom?

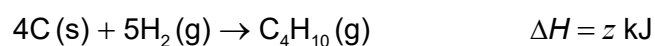
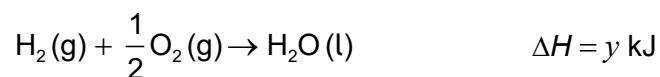
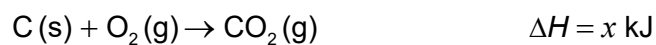
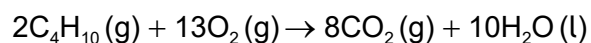
- I. CH_3COOH
- II. CH_3COCH_3
- III. CH_2CHCH_2OH

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

13. Which can be represented with only one Lewis structure?

- A. CH_2O
- B. C_6H_6
- C. O_3
- D. NO_3^-

14. What is the enthalpy of combustion of butane in kJ mol^{-1} ?



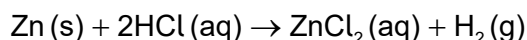
- A. $4x + 5y - z$
- B. $4x + 5y + z$
- C. $8x + 10y - 2z$
- D. $8x + 5y + 2z$

15. Which statement is correct?
- A. In an exothermic reaction, the products have more energy than the reactants.
 - B. In an exothermic reversible reaction, the activation energy of the forward reaction is greater than that of the reverse reaction.
 - C. In an endothermic reaction, the products are more stable than the reactants.
 - D. In an endothermic reversible reaction, the activation energy of the forward reaction is greater than that of the reverse reaction.

16. What is the enthalpy of solution of $\text{MgF}_2(\text{s})$ in kJ mol^{-1} ?

$$\begin{aligned} \text{Lattice enthalpy of } \text{MgF}_2(\text{s}) &= 2926 \text{ kJ mol}^{-1} \\ \text{Hydration enthalpy of } \text{Mg}^{2+}(\text{g}) &= -1963 \text{ kJ mol}^{-1} \\ \text{Hydration enthalpy of } \text{F}^{-}(\text{g}) &= -504 \text{ kJ mol}^{-1} \end{aligned}$$

- A. $2926 - 1963 + 2(-504)$
 - B. $2926 - 1963 - 504$
 - C. $-2926 - (-1963) - (-504)$
 - D. $-2926 - (-1963) - 2(-504)$
17. Which statement is correct?
- A. If $\Delta H < 0$, reaction is always spontaneous.
 - B. If $\Delta H > 0$, reaction is never spontaneous.
 - C. If $\Delta S < 0$, reaction can be spontaneous if temperature is low enough.
 - D. If $\Delta S < 0$, reaction can be spontaneous if temperature is high enough.
18. Which change increases the rate of formation of hydrogen when zinc reacts with excess hydrochloric acid, assuming all other conditions remain the same?



- A. Adding water to the hydrochloric acid
- B. Decreasing the temperature
- C. Increasing the volume of hydrochloric acid
- D. Decreasing the size of the zinc particles while keeping the total mass of zinc the same

Turn over

19. What are correct labels for the Maxwell–Boltzmann energy distribution curves?

	x-axis	y-axis
A.	progress of reaction	energy
B.	energy	progress of reaction
C.	probability density	kinetic energy
D.	kinetic energy	probability density

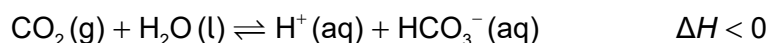
20. The reaction between NO_2 and F_2 gives the following rate data at a certain temperature.

$[\text{NO}_2] / \text{mol dm}^{-3}$	$[\text{F}_2] / \text{mol dm}^{-3}$	Rate / $\text{mol dm}^{-3} \text{ min}^{-1}$
0.15	0.20	0.10
0.30	0.20	0.40
0.15	0.40	0.20

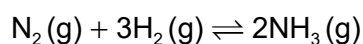
What is the overall order of reaction ?

- A. 3
- B. 2
- C. 1
- D. 0
21. What is the effect of increasing temperature on the rate constant, k ?
- A. The rate constant does not change.
- B. The rate constant decreases linearly.
- C. The rate constant increases exponentially.
- D. The rate constant increases proportionally with temperature.

22. What is the effect of increasing the temperature in this reaction?



- A. The pH will decrease.
 - B. The pH will increase.
 - C. CO₂ pressure will decrease.
 - D. The equilibrium position will shift to the right.
23. 1.0 mol of N₂(g), 1.0 mol of H₂(g) and 1.0 mol of NH₃(g) are placed in a 1.0 dm³ sealed flask and left to reach equilibrium. At equilibrium the concentration of N₂(g) is 0.8 mol dm⁻³.



What are the equilibrium concentration of H₂(g) and NH₃(g) in mol dm⁻³?

	[H ₂ (g)] / mol dm ⁻³	[NH ₃ (g)] / mol dm ⁻³
A.	0.2	1.2
B.	0.4	1.4
C.	0.4	0.4
D.	0.8	1.2

24. What describes HPO₄²⁻?

- A. Amphiprotic but not amphoteric
- B. Amphoteric but not amphiprotic
- C. Amphiprotic and amphoteric
- D. Neither amphiprotic nor amphoteric

Turn over

25. What is the pH of a solution in which the hydroxide ion concentration is $1 \times 10^{-11} \text{ mol dm}^{-3}$ at 298 K?

$$K_w = 1 \times 10^{-14} \text{ at } 298 \text{ K}$$

- A. 3
- B. 7
- C. 11
- D. 14

26. Which statements are correct?

- I. Lewis bases can act as nucleophiles.
- II. Electrophiles are Lewis acids.
- III. Lewis acids are electron pair acceptors.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

27. Which combination of acid and base is most likely to have a pH of 8.5 at the equivalence point in a titration?

- A. Hydrochloric acid and sodium hydroxide
- B. Hydrochloric acid and ammonia
- C. Nitric acid and ammonia
- D. Methanoic acid and sodium hydroxide

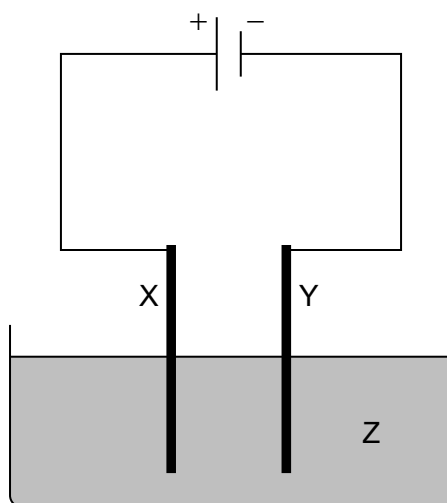
28. Which equation shows oxygen undergoing reduction?

- A. $2\text{F}_2 + \text{O}_2 \rightarrow 2\text{F}_2\text{O}$
- B. $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$
- C. $\text{H}_2\text{O}_2 + 2\text{HI} \rightarrow 2\text{H}_2\text{O} + \text{I}_2$
- D. $2\text{CrO}_4^{2-} + 2\text{H}^+ \rightleftharpoons \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$

29. What are the products of electrolysis when concentrated calcium bromide solution is electrolysed using graphite electrodes?

	Product at cathode (negative electrode)	Product at anode (positive electrode)
A.	hydrogen	bromine
B.	calcium	oxygen
C.	calcium	bromine
D.	hydrogen	oxygen

30. Which combination would electroplate an object with copper?



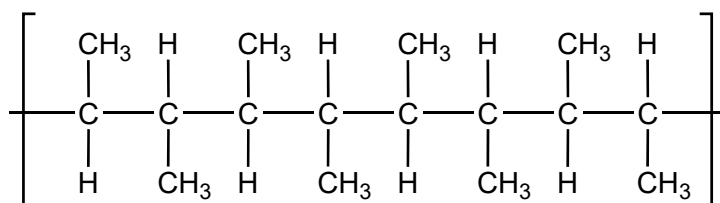
	X	Z	Y
A.	object	CuSO ₄ (aq)	copper
B.	copper	CuSO ₄ (aq)	object
C.	object	H ₂ SO ₄ (aq)	copper
D.	copper	H ₂ O (l)	object

Turn over

31. What does **not** affect the mass of products formed in electrolysis of an aqueous solution?
- A. Current
 - B. Duration of electrolysis
 - C. Initial mass of cathode
 - D. Charge on the ions

32. What is the product of the reaction between hex-3-ene and steam?
- A. Hexan-1-ol
 - B. Hexan-2-ol
 - C. Hexan-3-ol
 - D. Hexan-4-ol

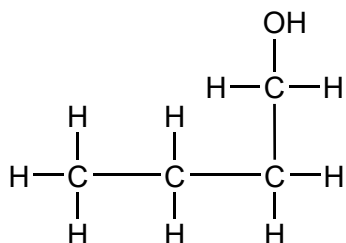
33. Which monomer could create this polymer?



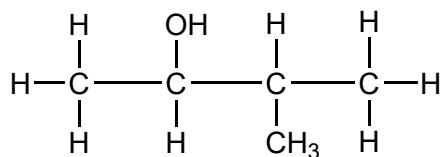
- A. But-2-ene
- B. But-1-ene
- C. Propene
- D. 2-Methylprop-1-ene

34. Which is a secondary alcohol?

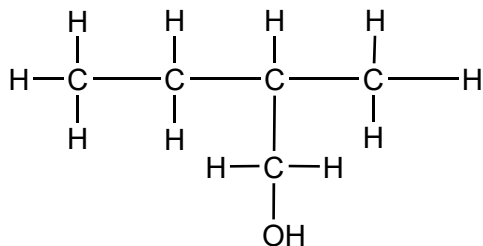
A.



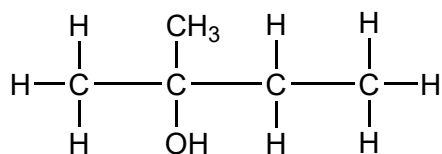
B.



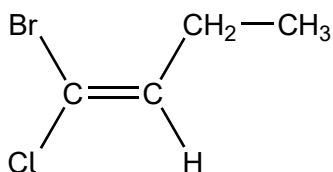
C.



D.



35. What is name of this compound applying IUPAC rules?



- A. E 1-bromo-1-chlorobut-1-ene
- B. Z 1-bromo-1-chlorobut-1-ene
- C. E 1-bromo-1-chloro-2-ethylethene
- D. Z 1-bromo-1-chloro-2-ethylethene

36. Which molecule contains a chiral carbon?

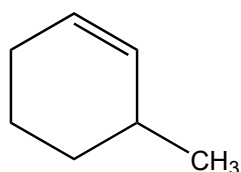
- A. $\text{CH}_3\text{CH}_2\text{CHBrCH}_2\text{CH}_3$
- B. $\text{CH}_3\text{CH}_2\text{CHBrCH}_3$
- C. $\text{CH}_2\text{BrCH}(\text{CH}_3)\text{CH}_2\text{Br}$
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$

Turn over

37. Which reagents are needed to convert nitrobenzene to phenylamine in 2 steps?

	Step 1	Step 2
A.	tin and sodium hydroxide	concentrated hydrochloric acid
B.	sodium hydroxide	tin and concentrated hydrochloric acid
C.	concentrated hydrochloric acid	tin and sodium hydroxide
D.	tin and concentrated hydrochloric acid	sodium hydroxide

38. What is the IHD, index of hydrogen deficiency, of 3-methylcyclohexene?



- A. 0
- B. 1
- C. 2
- D. 3
39. What is the ratio of the areas of the signals in the ^1H NMR spectrum of pentan-3-ol?
- A. 6:4:1:1
- B. 6:2:2:2
- C. 5:5:1:1
- D. 3:3:2:2:1:1
40. Which would be the most effective method to distinguish between liquid propan-1-ol and propan-2-ol?
- A. Observation of colour change when warmed with acidified potassium dichromate
- B. Determination of m/z value of molecular ion in the mass spectrum
- C. Determination of percentage composition
- D. ^1H NMR spectroscopy